IOP Conf. Series: Journal of Physics: Conf. Series **1126** (2018) 012024 doi:10.1088/1742-6596/1126/1/012024

Articulation of environmental management in projects of non-conventional energy sources in the Caribbean Colombian region

Y D Cardenas[1], **G E Valencia**[2] **and C H Acevedo**[3]
[1] Grupo de Investigación GIOPEN, Universidad de la Costa, Barranquilla, Colombia
[2] Efficient Energy Management Research Group, Universidad del Atlántico, Barranquilla, Colombia
[3] Departamento de Ingeniería Mecánica, Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia

E-mail: ycardena6@cuc.edu.co

Abstract. This work addresses an inclusion methodology based on criteria for the implementation of non-conventional energy sources and critical environmental factors for the licensing of the same, which is applied to the case study installation of wind turbines in seawater desalination plants in Isla Grande - Bolívar, this study was carried out taking into account field visits, and previous studies, where its main researchers and observers coincide with the authors of this article, the proposal includes aspects that involve the matrix of project stakeholders, work is completed with the qualitative and quantitative analysis of the factors of greater environmental impact, within the obtained results it is emphasized that the greatest impact that this project makes to 170 habitants of Isla Grande Bolivar is the changes of the current and/or potential use of soil, soil contamination and displacement of birds, In mammal, reptile and amphibian communities, it is suggested that Environmental Management Plans (PMA) be implemented, such as programs for conservation management, soil resource management, and vegetation and wildlife management programs, allowing for effective licensing of the project benefiting equally the interest group.

1. Introduction

In relation to the growing concern on the part of the state to reduce energy consumption and make good use of natural resources, society has opted for the design, implementation, monitoring, and evaluation of Non-Conventional Energy Sources (NCES) projects [1], thus achieving a social management of energy projects at the global level, Mexico for example analyses the contributions and shortcomings of the $2013-2014$ energy reform, with the aim of suggesting some alternatives for improvement considering the governance problems underlying the spiral of conflict that arises with the presence of NCES project developers in the communities [2], Argentina, on the other hand, is a country with a high potential of NCES, yet it is a country with little participation in the world energy matrix, contributing only 9% of its share in energy generation with NCES [3]. In its energy policy, Russia highlights its two branches according to different ontological assumptions, theoretically impregnated with geopolitics and ontologically materialistic, in order to analyze the projection of NCES to foreign energy [4]. In relation to the integration of the energy markets in Latin America, the Brazilian and Paraguayan hydroelectric dam Itaipu stands out, with $14000MW$ of installation capacity in Uruguay, Salto Grande Dam with a

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

capacity of $1890MW$ [5]. In general, all the countries of the world have considered the use of NCES as an active promoter of electricity generation.

Because of the above, it should be noted that the implementation of the NCES has inherent environmental, social and economic impacts, which must be managed and evaluated to achieve the success of the project (construction and licensing), adjusted to the economic and social conditions of the place. Environmental management and assessment is a measure that allows monitoring, analyzing and evaluating the Environmental Management System (EMS) of projects in a specific locality or area [6]. Environmental management represents an organizational change and involves a major effort to self-regulate and define a set of policies, objectives, strategies and administrative procedures to improve environmental performance in different projects [7]. The country that is recognized for its management and regulatory frameworks in the environmental area corresponds to New Zealand with a strong commitment in the administration of natural resources [8], Brazil for its part, analyzes the incorporation of environmental management in the organizational structure of companies and projects of NCES in search of improving their relationship and impacts with the environment [9].

Finally in Colombia environmental management has been included through the [10] where it is proposed to achieve the balance between the environment, society and the economy, essential for satisfying the needs of the present without jeopardizing the ability of future generations to satisfy their needs [11] in Colombia, the procedure for obtaining an environmental license for a project is governed by Decree 2041 of October $15, 2017$ [12] which specifies for each type of project, the competent environmental authority (which may be the Ministry itself as well as regional autonomous corporations, municipalities, etc.) and the type of documentation to be presented, this license is based on the requirement of environmental assessment, which includes different studies and technical analyses that allow the effects of a given project, work or activity to be estimated and in which the possible negative and positive impacts are projected, seeking to generate a lesser effect on the environment [13].

Currently, there are different methods of Environmental Impact Assessment (EIA) that allow the analysis of the predictable consequences of the action or effects of a given human action on the environment in its different aspects [14] these methods are based on lists, networks of interactions, interaction matrices (cause/effect), cartographic systems, indicators or indexes, multi-criteria, simulation or prediction tools, software for evasion, Ad-Hoc methods, etc.., that achieve that in one way or another the inclusion of the environmental component in the management and direction of projects, especially NCES projects, as shown in Table 1.

Table 1. The interrelation between methods and phases of non-conventional energy source projects.

EIA Methods	The direction towards the articulation of environmental management	Articulation phase in NCES Projects
Listings	Describes the project and identifies environmental impacts.	Strategic planning
Based on networks of interactions	Values the attributes of the impact measurement cumulative.	Verification
Interaction matrices (cause/effect)	Analyzes the relationship between aspects, impacts and engineering activities designing tools for the calculation of environmental impact.	Implementation and operation
Cartographic systems	Analyzes the physical space for project implementation and operation.	Strategic planning
Indicator or index methods	It calculates the environmental impact by environmental component and, of the impact with the help of transformation functions	Verification
Quantity or quantitative methods	Quantitatively corrects the input data for the analysis.	Verification
Multi-criteria analysis	It calculates the environmental impact taking into account the units of importance of the media, systems, components and parameters.	Operation

The main contribution of this article is the presentation of a methodology for the inclusion of environmental management and the evaluation and formulation of NCES projects in the Caribbean region of Colombia, applied to the case of the project for the installation of wind turbines in seawater desalination plants in Isla Grande, Bolivar.

2. Methodology paper

The proposed methodology presents an alternative way of articulating the elements of management (analysis, environmental assessment, and technical proposal) with the stages of the elaboration of a process project (Start, organization, execution, and closure). This methodology is broken down into two general steps.

2.1. Step 1: Development of the inclusion diagram

Critical factors of environmental management are linked to the formulation and elaboration of a project considering the functional analysis and processing of environmental indicators that includes a sustained NCES project.

2.2. Step 2: Breakdown of criteria

In this step, the functional analysis is developed taking into account the basis and constraints of the project to be evaluated show Table 2.

Table 2. Articulation of environmental management and formulation of non-conventional energy source projects.

Functional analysis	
Performance criterion	Critical factor
1. Adjustment of the project to the public environmental policies in force in the country and the area of execution.	Regulations and regulation.
2. Addressing and coordinating those interested in the project for the use of NCES.	The relationship between stakeholders for the implementation and operation of the project.
3. Implementation of the operation plan.	Methodology for Environmental Impact Assessment in the affected area.
4. NCES project operationalization.	Review for environmental licensing.

3. Results analysis

3.1. Environmental inclusion diagram

Taking into account the functional analysis of the articulation, the functionality diagram or also called the Environmental Inclusion diagram, shown in Figure 1, is developed.

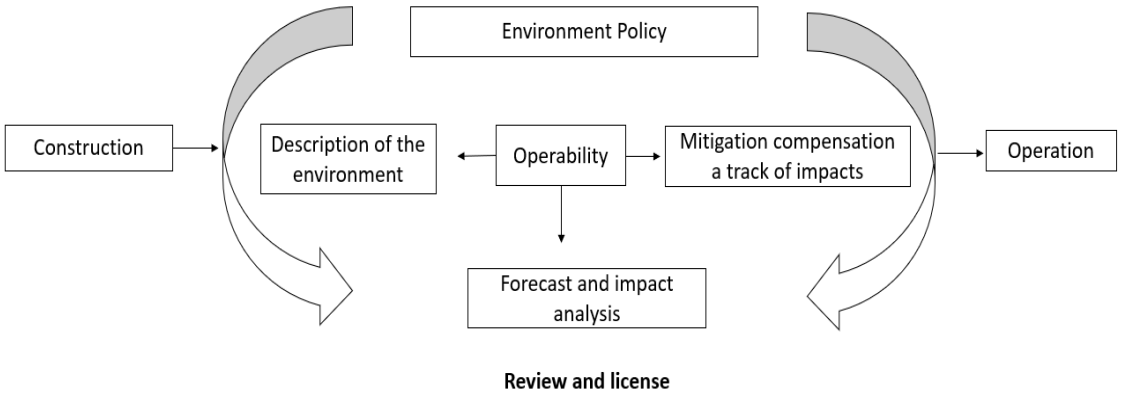

Figure 1. Articulation of environmental management and formulation of NCES projects.

3.2. Breakdown of criteria

Considering Table 2, the functional analysis of the wind energy project for seawater desalination plants in Isla Grande - Bolívar is performed, location is shown in Figure 2.

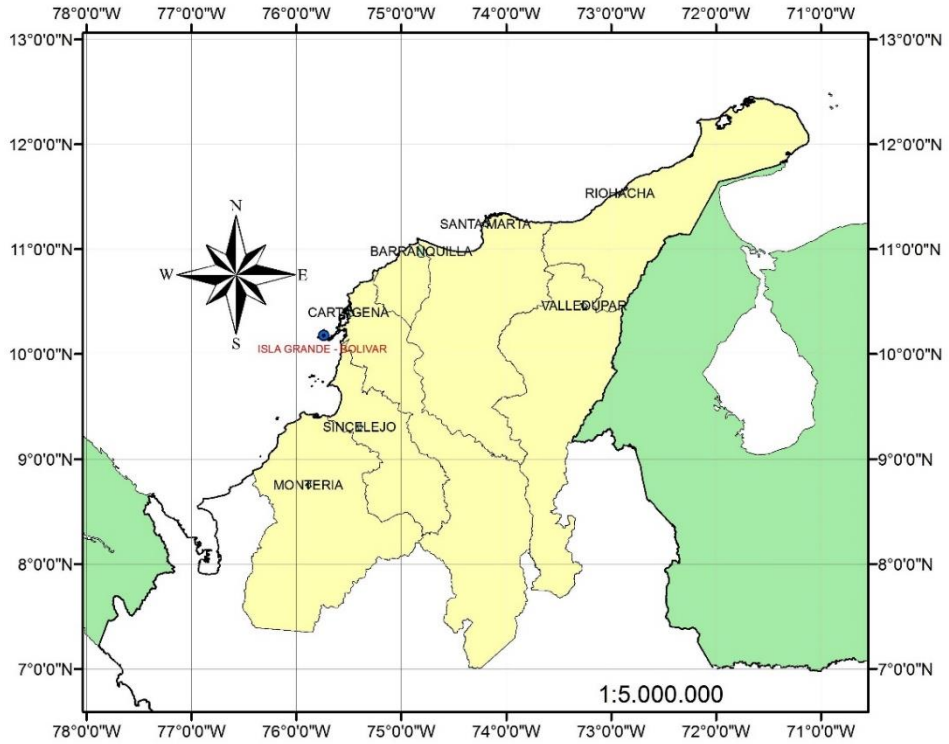

Figure 2. Location of the town of Isla Grande, Bolívar [15].

3.2.1. Criterion 1. In order to comply with this criterion, it is necessary to review the bibliography of the current regulations and regulations of the project. For the case study, it was obtained that projects of this type are naturally governed by two types of regulations, the first of which covers the technical standards of water quality, water control, water courses, etc., and the second related to the installation of Renewable Energy Technologies, among them, for the first group of regulations [16-22].

3.2.2. Criterion 2. In the second criterion related to addressing and coordinating stakeholders, it was found that this group includes the target population of 170 families in Isla Grande - Bolívar, Bolívar governorate, Cartagena mayor's office, industrialists in the home public services sector, and public providers. However, environmental interest is also exercised by secondary interest groups such as environmental associations, the media, NGOs, etc., which also have a significant impact on production operations, either directly or indirectly, for example, through legislative initiatives. The variables and indicators for the analysis of stakeholder targeting are based on the economic analysis relationship each of them has with critical environmental aspects in the area.

3.2.3. Criterion 3. For this criterion it is highlighted that the Environmental Impact Assessment Methodology is carried out in the area in two qualitative and quantitative ways: firstly, the environmental factors, the weighting of the project's impact on the environment, the effects of the actions, the importance of the effects and finally a qualitative analysis are evaluated. In this phase, the aim is to obtain an estimate of the possible effects that the wind project will have on the environment through the linguistic description of the properties it contains. For the quantitative evaluation of the wind energy project in seawater desalination plants in Isla Grande - Bolívar, the measurements of the magnitude of impact, environmental quality, the value of impact and finally a global analysis of this are highlighted.

In this order of ideas, the qualitative evaluation of the project showed that the identification of environmental factors is hierarchically correlated, as shown in Figure 3, focusing on the environmental systems and subsystems most affected.

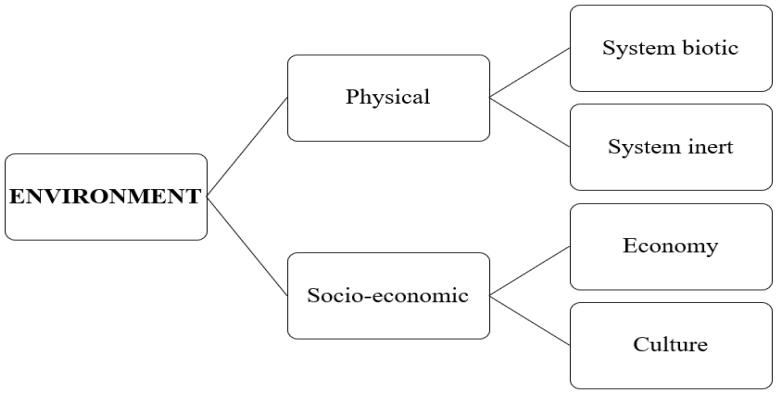

Figure 3. Environmental factors of the wind energy project in seawater desalination plants in Isla Grande, Bolívar

In relation to possible environmental impacts, it stands out: for water, air, soil and landscape, generation of clean energy, changes in the landscape, superficial alteration of drains, alluvial margins and strips, air pollution due to the temporary increase of vehicles in the area, development of erosive processes, changes in the current and/or potential use of soil, soil contamination, flora and fauna, loss of plant cover, displacement of birds, affectation of mammal, reptile and amphibian communities, collision of birds with the wind turbines and/or with the drivers of the connection line, transformation of the habitat on the social and economic environment, generation of employment, strengthening of the regional economy, generation of expectations in the community, strengthening of conflicts with the community, affectation of daily life, increased risk of accidents, affectation/improvement of road infrastructure, displacement of families, affectation of archaeological heritage.

The determination of the highest impact value was calculated using the environmental impact value Equation (1) or weighted value as

$$VIA = \left(P * W_p\right) + (I * W_i) + (E * W_e) + (D + W_d) + (R * W_r) \quad (1)$$

Where P is the probability, I is the intensity, E is the extension, D is the duration, R is the reversibility, Wp is the weight of the probability, Wi is the weight of the intensity, We are the weight of the extension, Wd is the weight of the duration and Wr is the weight of the reversibility.

It is important to note that the rating scales of the scale range numerically between 0 and 1 with assignment values between 0.01 and 0.19, between 0.2 and 0.39, between 0.4 and 0.69, between 0.7 and 0.99, and of qualitative scales, very low, low, medium, high and very high respectively.

As a result, a qualitative impact analysis was obtained where the greatest value corresponds to changes in the current and/or potential use of soils, soil contamination and bird movement, and effects on a mammal, reptile, and amphibian communities.

Subsequently, the quantitative evaluation is carried out, in this phase technical studies are carried out that allowed the precision of numerically predicting each one of the individual impacts and that later on is carried out in a weighted grouping of the same, thus obtaining the numerical global prediction of the impact, this prediction is translated into environmental value and environmental quality, taking into account that this valuation still belongs to the qualitative range, then the measurement of the magnitude of the impacts with Equation 2 becomes pertinent, which is the quantitative estimation of the effect that this will have on the environmental factor, this estimation is made by the experts in each factor reflected in quality.

$$M_i = Ag_i\left(M_{i1}, \ldots M_{ij} \ldots M_{im}\right), \quad (2)$$

where, M_i is the magnitude of the total impact, M_{ij} magnitude of the impact produced by action on the factor, Ag_i corresponds to the aggregation function of the factor evaluated or taken into account, the units of the magnitude corresponding to the characteristics of the aggregation indicator, which implies the impossibility of comparing between impacts, so it is necessary to describe on a common scale the magnitudes of the impacts by means of an Environmental Quality scale using transformation formulae... where their evaluative range varies by 0 (unfavorable) and 1 (optimum), the means in which the magnitudes of the impact of the factors are measured being the net environmental quality with and without the project is calculated by means of Equation (3).

$$CA_{neta-i} = CA_i(M_{con-i}) - CA_i(M_{sin\,-i}), \tag{3}$$

Where the sub-indices I correspond to the transformation functions, however, the measure of includes the importance and quality of the impact factors correspond to the impact assessment shown in Equation 4.

$$\text{where, } a_i = \frac{I_{fi}}{MAX\, I_{fk}}, k = 1 \ldots n, \text{ y, } b_i = (CA_{neta-1})^2 \tag{4}$$

Thus, the quantitative analysis applied to the wind energy project for seawater desalination plants in Isla Grande - Bolívar was obtained, where it was found that in coincidence with the qualitative analysis, the greatest value corresponds to changes in the current and/or potential use of soils, soil contamination and bird movement, affecting mammal, reptile, and amphibian communities.

3.2.4. Criterion 4. In relation to the operation of the NCES project, focused on environmental licensing, corrective measures are assigned or, failing that, PMA Environmental Management Plans that allow the mitigation of the impact factors evaluated with greater value in the previous step, in this case, programs are formulated, for example, for the management, conservation and restoration of the land, Waste management program, soil resource management program, vegetation and fauna management program with their respective projects aimed at mitigating the impact, in addition to mitigation should be compensated to the community of Isla Grande, for the use of land, this compensation can be made in fixed annual value per MW installed for example. And from this perspective, the project includes environmental management from start to finish.

4. Conclusions

This article presents the results of the methodology for the inclusion of environmental management and the evaluation and formulation of NCES projects in the Caribbean region of Colombia, applied to the case of the project for the installation of wind turbines in seawater desalination plants in Isla Grande, Bolivar through the articulation diagram, considering the functional analysis of NCES projects in parallel with the environmental management diagram. The identification and evaluation of the impacts were carried out using the detailed diffuse assessment method which evaluates the qualitative and quantitative criteria of the experts and the information collected in the study area.

The development of the functional analysis allowed to know the criteria for execution of an NCES project implies intrinsically to adjust to the critical factors that this entails in relation to environmental impacts. As for the regulations, it is important to highlight that they can be applied to the different projects, thus allowing us to know the parameters and/ or restrictions that this allows, where the assessment of EIA can be carried out from the qualitative or quantitative point of view, considering aspects that intervene in the interests of each of the project participants. Licensing of the project is successful if a relevant study of the project including social, economic and environmental aspects is carried out.

Acknowledgments
This research was supported by Facultad de Ingeniería of Universidad del Atlántico. G. Valencia is supported by the Efficient Energy Management Research Group Kai, Y. Cardenas is supported by the Grupo de Investigación GIOPEN from the Departamento de Energía Department of Universidad de la Costa, and C. Acevedo is a full time professor from Universidad Francisco de Paula Santander.

References

[1] Biyik E 2017 International Journal A key review of building integrated photovoltaic (BIPV) systems *Eng. Sci. and Tech* **20** 833-858
[2] Morales-Acevedo 2014 Forecasting future energy demand: Electrical energy in Mexico as an example case *Ener. Proc* **57** 782-790
[3] Fahmy F, Farghally H, and Ahmed N 2014 Photovoltaic-biomass gasifier hybrid energy system for a poultry house *International Journal of Modern Engineering Research* **4(8)** 51-62
[4] Ocelík P and Osička J 2014 The framing of unconventional natural gas resources in the foreign energy policy discourse of the Russian Federation *Ener. Pol* **72** 97-109
[5] Chávez-Rodríguez M, Varela D, Rodrigues F, Bustos J 2017 The role of LNG and unconventional gas in the future natural gas markets of Argentina and Chile *Jour. of Nat. Gas. Sci. Eng* **45** 584-598
[6] Panya N, Poboon C, Phoochinda W, and Teungfung R, 2017 The performance of the environmental management of local governments in Thailand *Kaset. Jour. Soc. Sci* **39** 33-41
[7] Rebelo M, Santos G, and Silva R 2016 Integration of management systems: Towards a sustained success and development of organizations *Jour. of Clean. Prod* **127** 96-111
[8] Lazkano I, Nøstbakken L, and Pelli M 2017 From fossil fuels to renewables: The role of electricity storage *Eur. Econ. Rev* **99** 113-129
[9] Davis A, Severnini E, and Jaramillo P 2017 The local socio-economic impacts of large hydropower plant development in a developing country *Ener. Econ* **67** 533-544
[10] International Organization for Standardization (ISO) 2015 Environmental management systems — Requirements with guidance for use, ISO 14001:2015 (Switzerland: International Organization for Standardization)
[11] Gil C, Cardenas Y 2017 Pest Analysis of Smart Energy Grid: from the European boom to the incipient emergence in Colombia *Contemporary Engineering Sciences* **10(21)** 1025-1034
[12] Ministerio de Medio Ambiente y Desarrollo Sostenible 2014 *Decreto 2041* (Colombia: Ministerio de Ambiente y Desarrollo Sostenible)
[13] Barma M, Saidur R., Rahman S, Allouhi A, Akash B, and Sait S, 2017 A review on boilers energy use, energy savings, and emissions reductions *Renew. and Sustain. Ener. Rev* **79** 970–983
[14] Bilgin A 2015 Analysis of environmental impact assessment (EIA) directive and the EIA decision in Turkey *Envi. Imp. Asses. Revie* **53** 40-51
[15] Cardenas Y 2013 *Banco de proyectos prioritarios para el aprovechamiento del potencial solar y eólico en la región caribe colombiana* (Barranquilla: Universidad del Atlántico) pp 1-129
[16] Ministerio de Medio Ambiente y Desarrollo Sostenible 1974 *Decreto Ley 2811* (Colombia: Ministerio de Ambiente y Desarrollo Sostenible)
[17] Ministerio de Salud Pública 1986 *Resolucion 2314* (Colombia:Ministerio de Salud Pública)
[18] Presidencia de la Republica de Colombia 1989 *Decreto 1700* (Colombia: Presidencia de la República de Colombia)
[19] Ministerio de Desarrollo Económico 1997 *Decreto 3102* (Colombia: Ministerio de Desarrollo Económico)
[20] Ministerio de Salud Pública 1998 *Decreto 475* (Colombia: Ministerio de Salud Pública)
[21] Congreso de la Republica 2002 Normas en materia tributaria y penal del orden nacional y territorial; y se dictan otras disposiciones *Ley 788* 1-76
[22] Congreso de la República de Colombia 2014 *Ley 1715* (Colombia: Congreso de la República de Colombia)